United States General Accounting Office

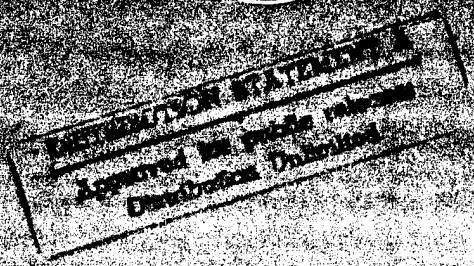
GAO

Report to the Ranking Minority Member, Subcommittee on Nuclear Regulation, Committee on Environment and Public Works, U.S. Senate

June 1992

URANIUM ENRICHMENT

Unresolved Trade Issues Leave Uncertain Future for U.S. Uranium Industry



GAO/RCED-92-104

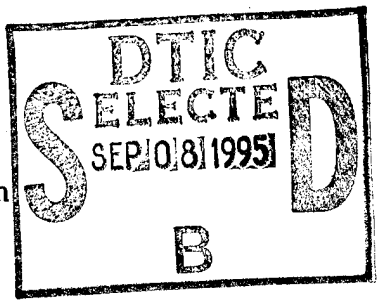
GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-237747

June 19, 1992



The Honorable Alan K. Simpson
Ranking Minority Member
Subcommittee on Nuclear Regulation
Committee on Environment and
Public Works
United States Senate

Dear Senator Simpson:

Jun 92

Uranium Enrichment: Unresolved Trade Issues Leave Uncertain Future for U.S. Uranium Industry

In 1991, total imports of Soviet-produced natural and enriched uranium[1] into the United States were 17 times greater than they were in 1986. Department of Energy (DOE) uranium enrichment officials and U.S. miners have viewed these imports as a threat to the domestic uranium market, and in November 1991, the miners filed an antidumping petition against Soviet importers.

In accordance with your request and later discussions with your staff, this report discusses (1) the increasing amount of natural and enriched uranium imported into the United States from the Soviet Union; (2) the ongoing antidumping case initiated by U.S. uranium miners; (3) other factors that will play a large role in determining the future of the domestic uranium market, namely, the breakup of the Soviet Union and the commercial use of highly enriched uranium (HEU)[2] originally produced for nuclear weapons; and (4) DOE's uranium inventories. Detailed responses to your questions on Soviet uranium production methods and costs and DOE's uranium inventories are contained in appendixes III and IV, respectively.

Throughout this report, we refer to the Soviet Union when we describe that nation's activities that took place before December 1991, and the Commonwealth of Independent States (CIS) or former Soviet republics when we talk about events that took place after December 1991.

[1]Uranium enrichment is the process that separates natural uranium into two components, one containing a higher content of fissionable material. DOE's uranium enrichment plants are the only facilities that provide enrichment services in the United States. Private nuclear fuel cycle companies called fabricators convert enriched uranium into fuel for nuclear reactors.

[2]HEU generally contains over 90 percent fissionable material, while the enriched uranium used in commercial reactors contains between 2 and 5 percent. HEU is used in nuclear weapons and fuels U.S. Navy nuclear reactors.

Results in Brief

U.S. imports of Soviet natural and enriched uranium totaled over 6.7 million pounds[3] in 1991—about 17 times more than they were in 1986. These imports now represent about 17 percent of the annual U.S. nuclear requirements; but the majority of the U.S. imports of foreign uranium continue to come from other countries such as Canada and Australia.

Domestic uranium miners, claiming that they have been injured by the sale of Soviet uranium and related enrichment services at less than their fair market value, filed an antidumping petition with the International Trade Commission (ITC) and the Department of Commerce's International Trade Administration (ITA) in November 1991. DOE, while not a formal petitioner, testified at an ITC public hearing that its enrichment business has been injured by low Soviet enrichment prices and provided requested information to both agencies. If ITC determines that the domestic market is being materially injured by Soviet/CIS imports, ITA will decide on import duties later this year.

The breakup of the Soviet Union and the potential commercial sale of HEU are also creating an uncertain uranium market. The breakup of the Soviet Union in late 1991 raises questions about how future uranium trading will be conducted. Uranium brokers and traders told us that it may take years before the new republics define new uranium trading policies. The breakup of the Soviet Union has also led to the possibility that large amounts of HEU originally produced for nuclear weapons will be processed for commercial use. A high-level DOE task force concluded in July 1991 that HEU removed from U.S. nuclear weapons as a result of initial arms reduction steps should not enter the commercial market. Since then, however, additional U.S. weapons cutbacks and Soviet initiatives to sell excess HEU to the United States have increased the possibility that some HEU will eventually be converted to commercial fuel. However, no decisions that could lead to the commercial sale of converted HEU have been made.

Because of its large uranium inventories, DOE does not intend to purchase any natural uranium in the foreseeable future. Furthermore, DOE officials

[3]Uranium can be imported in several different forms. When describing aggregate uranium imports, it is necessary to convert the various kinds of imports to a common weight factor. Because uranium oxide (U_3O_8), or yellowcake, is a common form of natural uranium, aggregate uranium statistics are often expressed in terms of U_3O_8 equivalent weight. Unless otherwise noted, uranium statistics in this report are expressed in terms of U_3O_8 equivalent weight.

expect to overfeed[4] the enrichment plants with some of the natural uranium that was set aside in 1985 for defense purposes. DOE officials say that DOE no longer needs this stockpile because it is no longer producing HEU for defense purposes.

Background

The U.S. uranium mining industry and DOE's uranium enrichment program have operated under a series of changing market conditions. In the early 1970s, the U.S. mining industry provided most of the natural uranium needed by the domestic nuclear power industry, while DOE and its predecessor agencies provided almost all enrichment services to western nations' nuclear utilities. Currently, however, the mining industry and DOE are struggling to compete against foreign competitors. (For a more detailed background discussion of the U.S. uranium industry, see app. II.)

In the late 1940s, the Soviet Union began enriching uranium for nuclear weapons. By the mid-1970s, V/O Techsnabexport (TENEX), the marketing arm of the Soviet Ministry of Atomic Power and Industry, had signed contracts with firms in almost all west European countries. According to market experts, by the 1980s, the Soviet Union had established a reputation as a dependable supplier of enrichment services in Europe.

In 1991, TENEX signed a contract with CONCORD—a collection of U.S.-based companies including NUEXCO, a large uranium trading and market information company—to create a joint venture called Global Nuclear Services and Supply Ltd. (GNSS) to market Soviet enriched and natural uranium. Since the joint venture was formed, available information indicates that all U.S. imports of Soviet natural and enriched uranium have been arranged and managed by GNSS.

U.S. Imports of Soviet Uranium Have Increased Dramatically Since 1986

According to import data compiled by DOE's Energy Information Administration (EIA), very little Soviet uranium entered this country for domestic end use before 1986. Most of the Soviet uranium that entered the country during this time (over 94 percent) was fabricated into nuclear fuel at a U.S. plant and reexported for use overseas.

According to DOE officials and other market experts, the Soviets began penetrating the U.S. enriched uranium market in about 1986 by selling

[4]Overfeeding refers to DOE's practice of feeding its own natural uranium into its enrichment plants in addition to the natural uranium provided by utilities in order to reduce the cost of producing enriched uranium for its customers.

enrichment services for as low as $50 to $55 per separative work unit (SWU)[5] —about one-half of DOE's contract price at the time. For the years 1986 through 1989, Soviet imports were relatively small (about 3.5 million pounds), and all were in the form of enriched uranium. However, DOE uranium enrichment officials say that these data do not reflect the true impact of increased Soviet enriched uranium sales at that time because they do not capture the effect of numerous exchange transactions. DOE uranium enrichment officials believe that Soviet enriched uranium was often shipped to European suppliers, who then shipped European-produced enriched uranium to the United States. These "swaps" took place, according to DOE, because U.S. utilities or their brokers did not want to be criticized for directly purchasing uranium from the Soviets during the Cold War.[6]

Beginning in the late 1980s, a number of circumstances led the Soviets to try to increase their uranium exports. After the Soviets ceased producing HEU for military purposes in 1987 and the Soviet commercial nuclear power program declined following the 1986 Chernobyl accident, available enrichment capacity increased, and large uranium inventories originally dedicated to the Soviet weapons program became available for sale. Additionally, according to DOE officials, worsening Soviet economic problems led to an increased emphasis on exporting uranium and related enrichment services—one of the few commodities the Soviets could readily export for hard currency.

U.S. imports of Soviet uranium jumped significantly from 1989 to 1990. According to data compiled by EIA, imports of Soviet uranium increased from about 1.5 million pounds in 1989 to over 6.5 million pounds in 1990—an increase of over 300 percent. Another 6.8 million pounds of Soviet uranium came into the country in 1991. From 1986 to 1991, annual imports of uranium from the Soviet Union increased by a factor of 17, or over 1,600 percent. A portion of these imports continued to be reexported after fabrication or other processing. According to EIA reports, about 10 percent of all uranium imported into the United States from 1986 to 1991 from the former Soviet Union has been reexported after being fabricated into nuclear fuel at a U.S. plant. Table 1 shows total annual Soviet uranium imports into the United States from 1986 through 1992.

[5]A SWU is a measure of effort required to separate uranium into components, including one containing a greater amount of fissionable material.

[6]For a discussion of initial Soviet uranium imports, see our December 1986 report, Uranium Enrichment: U.S. Imports of Soviet Enriched Uranium (GAO/RCED-90-70BR).

Table 1: Soviet Uranium Imports Into the United States, 1986-91

Pounds of U_3O_8 equivalent in thousands

Year	Natural	Enriched	Total	Reexported
1986	0	385.7	**385.7**	158.4
1987	0	999.1	**999.1**	428.9
1988	0	626.7	**626.7**	354.2
1989	0	1,498.1	**1,498.1**	109.0
1990	3,331.0	3,172.4	**6,503.4**	453.9
1991	5,918.5	842.1	**6,760.6**	149.7
1992[a]	2,590.4	802.3	**3,392.7**	0
Total	**11,839.9**	**8,326.4**	**20,166.3**	**1,654.1**

[a]1992 data for January and February only. There were no reexports of Soviet-origin uranium in the first 2 months of 1992.

Source: EIA.

Between 1986 and 1989, only enriched uranium was imported from the Soviet Union. In 1990, about 51 percent of the Soviet imports were composed of natural uranium; and by 1991, natural uranium made up about 88 percent of total Soviet uranium imports. We could not determine exactly why this shift from enriched to natural uranium occurred, although NUEXCO reported that the former Soviet republics may have limited enriched uranium inventories; furthermore, other brokers commented that GNSS may have wanted to build a U.S. stockpile of Soviet natural uranium in order to relieve potential customers of any supply concerns caused by the recent changes in the former Soviet Union.

Other Foreign Countries Still Provide Most U.S. Uranium Imports

In order to appreciate the impact of increased Soviet uranium imports on the U.S. uranium market, it is important to compare the imports with (1) annual U.S. utility uranium needs, (2) other U.S. uranium imports, and (3) ongoing U.S. uranium production and U.S. enrichment sales. These comparisons show that the growing Soviet uranium imports are providing an increased proportion of U.S. nuclear utility requirements while other foreign uranium imports have continued to grow. Department of Commerce import statistics also show that most of the natural uranium imported in 1989 and 1990 came from Canada and Australia and that a large amount of the enriched uranium imported into the United States in 1991 came from Germany. From 1989 to 1990, U.S. natural uranium production continued to decline, a trend that began in the early 1980s.

U.S. nuclear reactors require about 40 million pounds of uranium per year. Thus, Soviet imports in 1991, which totaled about 6.6 million pounds after reexports, represented 16.5 percent of expected total U.S. needs. Although this is still a relatively small percentage of total requirements, it is a big jump from 1986, when Soviet imports represented much less than 1 percent of U.S. requirements. Furthermore, market experts point out that some U.S. utilities are constrained by long-term purchase contracts to buy domestically produced uranium and/or DOE enrichment services. As these contracts begin to expire in the mid-1990s, experts project that the percentage of CIS purchases could increase if CIS uranium and related enrichment services remain available at low prices.

It is also important to note that total U.S. imports of enriched and natural uranium have risen over the last decade. In particular, Canada and other producers have sold increasing amounts of natural uranium to the United States since 1980. In 1990, according to Department of Commerce statistics, Canada and Australia, the two largest exporters of natural uranium to the United States, provided almost 70 percent of all natural uranium imported into the United States, compared with about 9 percent from the Soviet Union. Available Commerce statistics also show that the vast majority of the enriched uranium (over 93 percent) that entered the United States in the first 9 months of 1991 came from Germany, which liquidated a large government stockpile. In summary, Commerce statistics show that while Soviet uranium imports are growing, most uranium imports are still coming from other countries.

As total imports have grown, U.S. natural uranium production has fallen dramatically since it peaked in 1980. In 1990, for example, domestic production totaled 8.9 million pounds, compared with 13.1 million pounds in 1988 and 43.7 million pounds in 1980. In 1981 about 247 uranium production facilities operated in the United States, but by the end of 1990, only 39 were operating. One uranium mining official, whose company recently closed two production sites, told us that the latest closings were the direct result of cheap Soviet uranium imports that kept the price of uranium well below production costs.

Table 2 compares total domestic uranium production, total U.S. uranium imports, and total Soviet uranium imports since 1980.

Table 2: U.S. Uranium Market Summary, 1980-91

Pounds of U_3O_8 equivalent in millions

Year	U.S. natural uranium production[a]	Total U.S. imports	Total Soviet imports
1980	43.7	**3.6**	**0.7**
1981	38.5	**6.6**	**0.2**
1982	26.9	**17.1**	**0.6**
1983	21.2	**8.2**	**0.8**
1984	14.9	**12.5**	**1.1**
1985	11.3	**11.7**	**0.2**
1986	13.5	**13.5**	**0.4**
1987	13.0	**15.1**	**1.0**
1988	13.1	**15.8**	**0.6**
1989	13.8	**13.1**	**1.5**
1990	8.9	**23.7**	**6.5**
1991	8.0	**23.6[b]**	**6.8**

[a]Includes production from U.S. mines that produce uranium as a by-product.

[b]EIA projection.

Source: EIA.

A DOE uranium enrichment official testified at the preliminary ITC antidumping hearing in December 1991 that the key impact of the availability of cheap Soviet enrichment services has been the loss of commitments to DOE for future purchases. The official also testified that DOE currently has a very large share of domestic market deliveries because of contracts that were signed up to 10 years ago. By the mid- to late-1990s, however, DOE projects that the CIS will have a significantly larger share of the U.S. market (the largest uranium market in the world) because of contracts being signed today and/or expected to be signed in the near future at prices considerably lower than DOE's current contract price. DOE testified that the Soviet percentage of new enrichment contract signings rose from 6 percent of all new contracts in 1990 to 36 percent of all new contracts signed in 1991. DOE estimates that by the end of 1992, the CIS will obtain 65 percent of all new contracts signed.

DOE based its estimate on information from a number of U.S. utilities that have either signed a letter of intent to purchase CIS enrichment services in the future or have their management's approval to pursue a contract with the CIS. We note, however, that utilities are generally not signing long-term contracts. For example, NUEXCO stated in its 1991 annual report that GNSS

executed only two long-term agreements with U.S. utilities as of early 1992. According to utility representatives, U.S. nuclear fuel buyers recognize that excess enrichment capacity exists worldwide and that they can solicit competitive bids for near-term enrichment services instead of committing to long-term contracts.

Soviet Antidumping Petition Filed by U.S. Miners

On November 8, 1991, the Ad Hoc Committee of Domestic Uranium Producers, representing a coalition of 13 U.S. mining and milling companies, and the Oil, Chemical and Atomic Workers International Union, representing uranium conversion and enrichment plant workers, filed a petition with ITC and ITA. The petition alleged that the U.S. uranium industry has been materially injured or threatened with material injury because Soviet uranium imports have been sold at less than fair value and requested import relief under the Tariff Act of 1930 (19 U.S.C. 1673a). The petitioners claimed that Soviet imports have penetrated the U.S. market at unfair prices, thereby suppressing uranium prices to unprecedented lows which threaten to extinguish the U.S. industry. According to the petitioners' calculations, Soviet natural and enriched uranium have been priced in the United States at less than half of their fair market value. DOE officials told us that the Department's official position regarding the petition is to cooperate fully with ITA and ITC and provide any factual information requested. In addition, a DOE official testified at the December 3, 1991, ITC public hearing that DOE's enrichment business has been injured by low Soviet enrichment prices.

As a result of the petition, ITC and ITA initiated investigations in accordance with each agencys' respective regulations. In December 1991, ITC made a preliminary determination that the domestic uranium industry may be materially injured or threatened with material injury by reason of imports of uranium from the Soviet Union, and on May 29, 1992, ITA announced that it had preliminarily determined that six former Soviet republics are selling, or are likely to sell, uranium products at less than their fair market value in the United States. Both agencies expect to make final determinations later this year. If ITC finally determines that the domestic industry has been injured and ITA finally determines that the Soviet imports have been unfairly priced, ITA will determine what duties, if any, will be levied on CIS and/or past Soviet uranium imports. The final ruling can then be appealed by either party to the U.S. Court of International Trade.

The breakup of the Soviet Union has made it difficult for ITA and ITC to accumulate data to support their market-injury and fair-pricing analyses. The agencies have had to contact 12 new republics, each in the throes of establishing a central government. To date, neither agency has received satisfactory responses to its questionnaire requesting uranium cost and production data from the former Soviet republics that have uranium mining or product centers. According to Commerce officials, because data have not been forthcoming, they are conducting a "surrogate analysis" using production and cost data from other countries whose technology is deemed comparable to Soviet technology to determine a fair market price. (See app. III for available information on Soviet uranium production and enrichment capabilities.)

The Dissolution of the Soviet Union and the Potential Commercial Use of HEU Add Further Uncertainty to the Uranium Market

The late 1991 dissolution of the Soviet Union's central government creates uncertainty as to how future uranium sales activities will be conducted. According to a January 31, 1992, GNSS submission to ITA, the Ministry of Atomic Power and Industry (MAPI)—the federal ministry of the former government of the Soviet Union, which centrally coordinated uranium production and sales—no longer exists. A new Russian Ministry of Atomic Energy has been established; the Ministry has no authority over uranium production or sales in any of the other former Soviet republics. TENEX—the foreign economic association that exported goods and services produced by MAPI prior to the dissolution—is now a joint stock company that continues to engage in exporting uranium but now must negotiate separately with each of the uranium-producing enterprises within the CIS that have asserted ownership and control over the uranium facilities located in their territories. Furthermore, according to trade press reports, some uranium facilities in the CIS other than Russia have begun to negotiate directly with prospective foreign customers without advising or consulting with TENEX. Uranium brokers and traders told us that the dissolution of the Soviet Union will have a dramatic effect on future uranium production sales and costs, and it will take months, if not years, for future uranium-trading activities to be defined.

The breakup of the Soviet Union has also increased the possibility that some HEU will be converted to commercial fuel for sale to nuclear power plants. In July 1991, a high-level U.S. task force determined that initial amounts of HEU removed from U.S. weapons would not be available for commercial use. However, since then, further U.S. weapons reduction decisions have been made, and the Cold War threat has declined because of the breakup of the Soviet Union. DOE officials now speculate that some

of the large amount of HEU that will be removed from retired U.S. nuclear weapons may eventually be used for commercial purposes. However, no specific decisions that would lead to the commercial sale of HEU have been made. One private-sector analysis concluded that if one-half of the U.S. inventory of HEU is blended down to commercial grade enriched uranium, it could meet about 20 percent of U.S. utilities' needs for enriched uranium for 20 years.

The breakup of the Soviet Union has also led to high-level discussions between the former Soviet Union and U.S. officials examining the possibility of transporting Soviet-produced HEU to the United States. Former Soviet officials have publicly announced that they can sell up to 500 metric tons of HEU. U.S. officials would like to obtain this material in order to reduce nuclear proliferation concerns.

DOE Has Large Uranium Inventories

DOE has over 450,000 metric tons of uranium in addition to its classified HEU inventories. Almost all of this uranium was originally purchased as natural uranium under government contracts prior to 1971. While some of this natural uranium still remains with DOE's uranium enrichment program, much of it has been enriched or otherwise processed and relocated throughout DOE's weapons and laboratory complex. DOE's total uranium inventory—which includes about 4,300 lines of inventory items—can be summarized into four categories: natural uranium; enriched uranium; HEU; and depleted uranium, or tails. Because of the size of their inventories, DOE officials said they will not need to purchase any uranium for the foreseeable future.

In 1985 DOE allocated the natural uranium remaining in its inventories to its commercial uranium enrichment and defense programs. Since then, the commercial program has used much of its allotment for overfeeding its enrichment plants. However, about 18,700 metric tons of natural uranium remained in the defense allotment at the end of fiscal year 1991. DOE officials expect that the commercial program will be able to eventually use some of this remaining natural uranium for overfeeding, since DOE decided last year to stop producing HEU for defense purposes. (For a more complete discussion of DOE uranium inventory issues, see app. IV.)

Conclusions

According to uranium market experts, it will probably take several years for the various parties involved to fully answer the following three questions:

1.How will the ongoing antidumping case be resolved?

2. How will the evolving former Soviet republics market uranium?

3. How much HEU will be "blended down," and when will it be available for sale?

Because the answers to these questions will determine, to a large extent, the future of the domestic uranium market, domestic uranium producers and DOE's enrichment program currently face an uncertain future.

In the meantime, U.S. uranium producers cannot expect DOE to create any new demand for natural uranium. DOE has large amounts of uranium in various forms and may someday be able to convert excess HEU obtained from retired nuclear weapons to commercial fuel. In addition, uranium enrichment officials are optimistic that they will be able to use some of the natural uranium set aside in 1985 for defense purposes for overfeeding.

Agency Comments

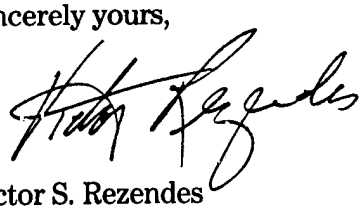
We discussed the factual contents of this report with DOE officials representing the Office of the Assistant Secretary of Nuclear Energy, the Uranium Enrichment Program, Defense Programs, and EIA. These officials generally agreed with the report and provided us with detailed comments and updated statistics that have been incorporated into the report where appropriate. However, as requested, we did not obtain written agency comments on this report.

We conducted our work between July 1991 and May 1992 in accordance with generally accepted government auditing standards except as noted in appendix I. (For a detailed description of our scope and methodology, see app. I.)

Unless you publicly announce its contents earlier, we plan no further distribution of this report for 30 days from the date of this letter. At that time, we will send copies to appropriate congressional committees; the Secretary of Energy; the Secretary of Commerce; the Chairman of the International Trade Commission; and the Director, Office of Management and Budget. We will also make copies available to others upon request.

Please contact me at (202) 275-1441 if you or your staff have any questions. Major contributors to this report are listed in appendix V.

Sincerely yours,



Victor S. Rezendes
Director, Energy Issues

Contents

Abbreviations

CIS	Commonwealth of Independent States
DOE	Department of Energy
EIA	Energy Information Administration
GNSS	Global Nuclear Services and Supply, Ltd.
HEU	highly enriched uranium
ITA	International Trade Administration
ITC	International Trade Commission
SWU	separative work unit
MAPI	Ministry of Atomic Power and Industry
TENEX	Techsnabexport

Scope and Methodology

To obtain information on uranium imports from the Soviet Union, we interviewed officials from DOE's Energy Information Administration (EIA), the International Trade Commission (ITC), and the Department of Commerce's International Trade Administration (ITA) in Washington, D.C. We also obtained available documents such as EIA's Uranium Industry Annual and Uranium From the U.S.S.R. (the preliminary determination of the ITC investigation of the Soviet antidumping suit). To obtain information on the current status of the uranium market and the impact of Soviet imports on the uranium market in the United States, we interviewed officials from NUEXCO, the New York Nuclear Corporation, NUKEM, and the Uranium Exchange Company, four companies active in the international uranium market. We also attended U.S. Council of Energy Awareness conferences on uranium in September 1991 and the nuclear fuel cycle in January and March of 1992.

To address questions on Soviet production practices, inventories, and costs, we interviewed officials and obtained documents from the Department of Energy's (DOE) Office of Intelligence, Washington, D.C.; the Uranium Institute, London, England; the International Atomic Energy Agency, Vienna, Austria; and NUEXCO, Denver, Colorado. Since little data are available on Soviet uranium inventories, production capabilities, costs, and practices, most of the information we obtained was in the form of expert estimates. To obtain information on DOE's uranium inventories, we interviewed officials and obtained inventory data from DOE's Office of Weapons and Materials Planning and Uranium Enrichment Program, Germantown, Maryland.

We primarily used import data compiled by the Department of Commerce and EIA. The EIA data were taken from DOE's Nuclear Management Information System and are used by DOE and the Nuclear Regulatory Commission to monitor all uranium shipped into the United States. We attempted to verify this import data by checking it against ITC's records developed during the antidumping petition filed against Soviet uranium importers by domestic uranium miners. However, ITC refused us access to uranium trade information because of its interpretation of 19 U.S.C. §1677f, which requires it to safeguard proprietary data provided to it during an antidumping investigation.

We discussed the information in this report with the Director of Business Operations for the Uranium Enrichment Program; the Director of Materials Planning within the Office of Defense Programs; and the Director of EIA's Office of Coal, Nuclear, Electric and Alternative Fuels. An

official within the Office of the Assistant Secretary of Nuclear Energy also reviewed the facts contained in the report. These officials generally confirmed the information contained in the report. Where appropriate, changes have been made on the basis of these discussions to further clarify the information presented. As requested, we did not obtain written agency comments on a draft of this report. Our work was conducted from July 1991 to May 1992 in accordance with generally accepted government auditing standards except as noted above.

Background

Uranium is a silvery white metal, used almost exclusively to produce fuel for nuclear reactors. Uranium is most often obtained from surface (open-pit) or underground mines or as a by-product during the production of other minerals, such as phosphate. It can also be extracted from the ground through a process called in-situ mining, whereby a dissolving solution is pumped through the uranium ore body, after which the solution and ore are extracted for processing. The natural uranium, usually in the form of uranium oxide, or "yellowcake," (U_3O_8) is usually converted to uranium hexafloride (UF_6), which is then converted to a gas and enriched. Uranium enrichment is the process that separates natural uranium into two components, including one with a higher content of fissionable uranium isotope—U-235.[1] The enriched uranium is further processed and eventually fabricated into fuel for use in nuclear power plants. In the past, some uranium has been highly enriched for use in nuclear weapons or U.S. Navy nuclear reactors. Enriched uranium to be used as commercial fuel is shipped to companies who fabricate it into fuel assemblies for nuclear power plants.

The U.S. uranium mining industry has operated under a series of changing business conditions since it began producing solely for the U.S. government in the 1940s and 1950s. In the 1970s, when uranium first became available to private customers, the domestic uranium miners were protected from foreign competition by a provision in the government's enrichment contracts which prohibited DOE from enriching imported uranium intended for domestic nuclear power plants. In 1980 domestic uranium mining production peaked because of the predicted rosy future for nuclear power and lucrative long-term contracts signed by nuclear utilities with natural uranium producers anxious to secure a safe, domestic source of uranium. In 1980 domestic miners produced 43.7 million pounds of uranium and employed about 12,000 people.

Since the early 1980s, however, the industry has struggled after restrictions on the use of foreign imports were eased and utilities cut back on expected nuclear plant construction. Furthermore, large uranium inventories acquired by utilities under earlier contracts created a secondary uranium short-term (spot) market, in which utilities sold their surplus inventories at prices below domestic production costs. By 1988 foreign investors had taken over most of the struggling U.S. uranium mining industry, and imports supplied 51 percent of U.S. utilities' requirements. Because of its poor financial state, the Secretary of Energy,

[1]Natural uranium contains about 0.71 percent of the fissionable isotope U-235. Enriched uranium for use in commercial reactors contains about 2 to 5 percent of the isotope, while highly enriched uranium used in nuclear weapons and U.S. Navy nuclear reactors contains over 90 percent U-235.

in an annual report required by the Atomic Energy Act, has declared the domestic uranium mining industry nonviable every year since 1984.[2] Nevertheless, by the end of the 1980s, the domestic uranium industry was generally optimistic because utilities' inventories were being reduced, natural uranium prices were rising, and a new mining technology (in-situ mining) appeared to have cost and environmental advantages that would enable U.S. producers to compete with Canada and Australia, the world's two leading producers.

As with the uranium miners, DOE's uranium enrichment program, the only U.S. entity that enriches natural uranium, has faced a dramatically changing business environment over the last 15 years. The program started out in 1969 with a monopoly over the western world's enrichment market. But with aging, energy-intensive production facilities, it finds itself facing stiff foreign competition. As a result, DOE's share of the western world's enrichment market declined from about 100 percent in the early 1970s to less than 50 percent in 1991.

[2]In order to help determine if the government should take steps to help domestic uranium miners, a 1983 amendment to the Atomic Energy Act has required the Secretary of Energy to annually determine if the domestic industry is viable for the 1983-92 period.

Soviet Union Uranium Production Capabilities

Little information is available on how uranium was or is produced in the former Soviet Union, what it cost the Soviets to mine or enrich the uranium, or the extent of uranium inventories in the CIS. This section summarizes available data and estimates of the former Soviet Union's uranium production practices, capacities, and costs. As noted in the report, the dissolution of the Soviet Union will have a dramatic effect on future uranium production, sales, and costs—and it may take years before the new republics define new uranium production and sales practices.

Soviet Natural Uranium Production and Costs

According to NUEXCO's 1991 Annual Review, 40 percent of the natural uranium produced in the former Soviet republics was recovered through in-situ leaching. Of recent uranium mining activity, about 30 percent of mine production has come from Russia, 30 percent from Kazakhstan, 30 percent from Uzbekistan, and the remaining 10 percent from Ukraine. In 1991, prior to the breakup, the Uranium Institute estimated total Soviet natural uranium production to have been 5,000 metric tons in 1990 and projected it to reach 10,000 metric tons by 1995. This compares with total annual U.S. requirements of about 18,000 metric tons.

According to available reports, the Soviet Union's former East European satellites of Bulgaria, Czechoslovakia, East Germany, and Hungary shipped natural uranium to the Soviet Union from 1946 to 1990. After January 1991, the Soviet Union no longer controlled the uranium operations of its former satellites, and no new contracts were signed. One private study estimates that the former Soviet Union's Eastern European satellites produced over 1.5 billion pounds of natural uranium between 1946 and 1990 for shipment to the Soviet Union.

DOE officials believe that past Soviet uranium production costs have been low because production was very labor-intensive, and at least in the past, Soviet labor was "cheap." However, some experts we talked to also said that the nonmarket economic conditions that existed in the Soviet Union and its satellites precluded anyone, including Soviet officials, from determining the true cost of past uranium production.

Soviet Uranium Enrichment Practices

In 1991 the Soviets operated four enrichment plants, two of which also have facilities for converting natural uranium to gas for use in the enrichment plants. According to a 1990 NUEXCO Annual Review, all four plants have gas centrifuge units, and gaseous diffusion enrichment accounts for less than 5 percent of their total output. According to

NUEXCO's 1991 Annual Review, a major enrichment upgrading program is underway to replace old-generation centrifuge machines with newer, more efficient machines. An official of the Soviet Ministry of Atomic Power and Industry stated in 1990 that all four centrifuge facilities are located in the Russian Republic.

Although the capacity of individual plants and the total capacity of all enrichment plants remained classified at the beginning of 1992, the NUEXCO 1991 report estimates that the four Soviet enrichment plants have a total capacity of at least 10 million separative work units[1] (SWU) per year. Furthermore, TENEX has announced that it will be able to export about 10 million SWU per year by the year 2000. No information is currently available on Soviet enrichment costs.

Soviet Uranium Inventories

The Uranium Institute estimates in its report Uranium in the New World Market Supply and Demand 1990-2010 that the former Soviet republics have a total stockpile of uranium in all forms of between 140,000 to 160,000 metric tons, excluding HEU for military purposes. According to DOE officials, Soviet officials have publicly announced that they can sell up to 500 metric tons of HEU to the United States. NUEXCO estimates that the Soviets do not have a large commercially enriched uranium inventory. Little information exists on what the former Soviet republics are doing with excess enriched uranium production (if any) since the breakup of the Soviet Union.

[1]A SWU is a measure of the effort required to separate uranium into components, including one containing a greater amount of fissionable material.

DOE's Uranium Inventories

Most of DOE's uranium was originally purchased by the Atomic Energy Commission by 1971. By 1971 the government had purchased over 600 million pounds of natural uranium (U_3O_8 equivalent) from domestic miners and from foreign sources when domestic producers could not meet government requirements. While some of this natural uranium remains under the control of DOE's uranium enrichment program, much of the purchased uranium has been enriched or otherwise processed and relocated throughout DOE's extensive weapons and laboratory complex. However, only a relatively small amount of uranium has been permanently removed from DOE's inventories through weapons testing or some other means. Even the highly enriched uranium (HEU) produced by DOE's enrichment program for military purposes and presently contained in nuclear weapons is considered part of DOE's uranium inventories.

DOE's unclassified materials inventory records list about 4,300 line items of uranium inventories. Each inventory item represents uranium in a different form, mixture, enrichment level, and/or location. The large number of different inventories shows how widespread and diverse DOE's total uranium inventory is. Because of the many different uranium inventories, and the difficulty in reconstructing past records, DOE officials told us that compiling an historical, year-by-year accounting of the changes in its uranium inventories would be an extremely complex, if not impossible job. However, DOE's total uranium inventory can be summarized in four broad categories: (1) natural uranium; (2) enriched uranium; (3) HEU; and (4) depleted uranium, or tails. All HEU (uranium enriched above 20 percent) inventory data are classified as are some small amounts of other forms of uranium that are assigned to specific DOE classified programs, such as the AVLIS program—DOE's new laser enrichment technology development program.

Table IV.1 shows DOE's unclassified uranium inventory as of the end of fiscal year 1991.

Table IV.1: DOE's Uranium Inventories as of October 1, 1991

In metric tons	
Uranium	**Total**
HEU	**(classified)**
Enriched	**12,294**
Natural	**60,158**
Depleted	**380,681**

Note: DOE's total uranium inventory is expressed in terms of the total aggregate weight of the various inventories regardless of its form or level of enrichment. For example, the total amount of enriched uranium shown in this table is the total of all of the enriched uranium inventories spread throughout DOE, even though the enrichment level varies from slightly above 0.7 percent (natural uranium) to 20 percent. DOE classifies uranium enriched above 20 percent as HEU.

DOE's Uranium Enrichment Program's Inventories

DOE officials told us that DOE's total uranium inventory has not changed significantly for many years because very little uranium has entered or been removed from the system. The only exception to this has been the natural uranium routinely provided to DOE's uranium enrichment program by utilities for enrichment and the enriched uranium ultimately provided to DOE's customers. Under DOE's uranium enrichment program, DOE takes title to natural uranium when it is delivered by its customers, even though it may not actually provide related enrichment services for many years. When DOE takes title to the uranium, it incurs an obligation to produce a given amount of enriched uranium per the terms of the enrichment contract. As of the end of fiscal year 1991, the enrichment program controlled about 79,000 metric tons of uranium[1] including about 64,100 metric tons of natural uranium. About 46,900 metric tons was provided by utilities and represents a future DOE liability to its enrichment customers.

The remaining inventories, about 32,100 metric tons, are dedicated to DOE's commercial uranium enrichment and defense programs according to a 1985 internal memorandum of agreement between DOE's Offices for Defense Programs and Nuclear Energy, which allocated the natural uranium remaining in DOE's inventories at that time. Since then, the Office for Defense Programs has used about 6,100 metric tons (about 25 percent) of its allocation mainly for nuclear Navy fuel and has about 18,700 metric tons left for defense purposes. The remaining amount (about 13,400 metric tons) is available for commercial purposes, including overfeeding. For

[1]DOE's uranium enrichment program expresses its inventory statistics in terms of the equivalent weight of natural uranium. In other words, regardless of its enrichment level, these statistics express the total weight of the inventory in terms of what it would weigh if the inventory were made up of natural uranium (0.7 percent enrichment). These statistics are not comparable to the total inventory statistics maintained by DOE's Office of Nuclear Materials, which does not convert the thousands of different DOE uranium inventories to an equivalent weight.

each of the last 4 fiscal years (1988-91), DOE has used over 3,300 metric tons of its natural uranium to overfeed its plants and cut production costs. Table IV.2 shows the annual inventory status of DOE's uranium enrichment program since 1985.

Table IV.2: DOE's Uranium Enrichment Program's Inventory Status, 1985-91

In metric tons of natural uranium equivalent

	DOE ending inventories					
Fiscal year	Natural uranium	Enriched uranium	Total	DOE's customer liability	Office of Defense Programs' allocation	Remaining uranium enrichment inventory
1985	47,215	35,335	**82,550**	25,762	24,802	31,986
1986	54,449	32,331	**86,780**	31,505	23,364	31,911
1987	61,928	27,562	**89,490**	36,927	21,766	30,797
1988	72,465	18,213	**90,678**	45,681	20,464	24,533
1989	71,057	13,072	**84,129**	44,595	19,387	20,147
1990	69,381	14,610	**83,991**	48,340	18,971	16,680
1991	64,085	14,908	**78,993**	46,897	18,719	13,377

DOE uranium enrichment officials plan to use the rest of DOE's natural uranium allotment for overfeeding over the next 10 years, according to a cost optimization model. Uranium enrichment officials also speculate that some of the defense allocation may become available for commercial overfeeding as large amounts of HEU are removed from nuclear weapons, thereby reducing the need for a large stockpile of natural uranium for defense purposes.

Table IV.2 also shows that as of the end of fiscal year 1991, DOE held about 46,900 metric tons of uranium provided to it by utilities. DOE officials told us in March 1992 that the program had never used any natural uranium provided to DOE by utilities for overfeeding. However, DOE officials told us that they could overfeed their enrichment plants by using utility-provided uranium as long as they meet their future contract commitments.

HEU

Although DOE stopped producing HEU for weapons purposes in 1964, DOE continued to produce HEU for use in the nuclear Navy, research reactors, and defense production reactors. In November 1991, DOE announced its plan to stop producing HEU; however, minimal production will continue until about November 1992, when necessary shutdown procedures will be

completed. Other required safety analyses and related environmental studies are expected to take about 3 years.

The decision to shut down DOE's remaining HEU production capacity was one of the recommendations of a high-level task force that was formed in 1991 to examine various HEU options in light of the large amounts of HEU that are expected to be removed from dismantled nuclear weapons under recent arms reduction agreements. The task force's classified report looked at how much HEU existed and how much might be removed from weapons, and examined options for disposition of the excess amounts.

The analyses performed by a task force working group concluded that the blending down of initial quantities of excess HEU to enriched uranium so that it could be sold to nuclear utilities was not economically advisable. According to DOE officials, the working group concluded that HEU could easily be blended down for commercial sale, and that economic benefits to the enrichment program could be substantial. However, the analysis balanced the relatively short-term benefits that could be obtained from blending initial returned HEU quantities for commercial sale against the future need to eventually produce additional HEU for defense purposes and concluded that it was cost-effective to postpone future HEU production as long as possible. The analysis also showed that even if blending were pursued, HEU could not be made available for commercial use for some time because of the time it takes to dismantle nuclear weapons and build a $100 million facility to convert HEU metal contained in weapons to uranium hexaflouride, which can be converted to a gas that can be blended down for commercial use.

Since the task force completed its work in July 1991, the Bush administration has announced other nuclear arms cutbacks and the possibility of obtaining HEU produced by the former Soviet Union has been discussed. According to DOE officials, U.S. and former Soviet officials have conducted a series of meetings to discuss the possibility of transferring HEU to the United States. According to DOE officials, former Soviet officials have publicly announced that they can sell as much as 500 tons of HEU.

One private study of the impact of blending down HEU for commercial sale hypothesized that if half of the U.S. HEU is reduced to commercial grade enriched uranium, it could replace about 7.5 million pounds of natural uranium and about 1.9 million SWU per year for 20 years, or about 20 percent of U.S. uranium and enriched uranium requirements over that time. The report also concluded that if half of the CIS HEU is reduced, it

could replace about 16.5 million pounds and 4.1 million SWU per year. Taken together, the report concludes that U.S. and CIS HEU could supply about 20 percent of the Western World's requirements for 20 years.

DOE Office of Nuclear Materials officials told us that they are preparing a first ever strategic uranium inventory plan that will consider the latest strategic and inventory requirements. The plan is expected to be completed in 1992 and be periodically updated as circumstances change.

Depleted Uranium (Tails)

A substantial portion of DOE's uranium inventory—over 380,000 metric tons as of the end of fiscal year 1991—is in the form of depleted uranium or tails. These tails were produced at the DOE enrichment plants, where two process streams are generated during the enrichment process: one with a higher than natural content of U-235, the isotope needed to spur nuclear fission, and another stream depleted in U-235. Generally, for every 7 pounds of natural uranium fed into the plants about 1 pound of enriched uranium is produced along with 6 pounds of depleted uranium or tails.

Per the terms of the enrichment contracts, utilities that provide natural uranium to DOE have the right to pick up the tails after enrichment occurs. According to DOE officials, few if any utilities have ever removed the tails from the plants. DOE enrichment contracts provide that if the utility does not exercise its option to acquire the tails, they become the property of DOE. The 1985 DOE memorandum that allocated uranium inventories between the defense and commercial programs states that the tails are the property of DOE's Office of Defense Programs.

Although the tails are depleted in U-235, that is they contain less U-235 than natural uranium, they still contain between 0.2 percent and 0.65 percent of U-235. Most of the tails contain about 0.2 to 0.25 percent of U-235 compared with natural uranium, which contains about 0.7 percent of U-235. DOE considers the tails a potential asset that could be used as a feed stream for future cost-efficient enrichment technologies. Whether these tails would ever be used as a feed stream depends on the future cost of natural uranium compared with the cost to reenrich these tails to the level of natural uranium.

Cost of Reenriching Tails

The key factor determining the cost of reenriching the tails is the cost per SWU. The cost to reenrich tails would also depend on the assay of the new tails or waste stream produced during the reenrichment process. From a

given amount of depleted uranium, one can produce more natural uranium with a lower tails assay. However, the lower the tails assay from the reenrichment process the more energy (SWUS) is required to extract the U-235 isotope from the depleted tails.

Table IV.3 shows the cost to produce a kilogram of natural uranium hexafloride from 0.2 percent depleted uranium tails, assuming various SWU costs and a final tails assay of 0.15 percent. According to the table, if a SWU cost $50, it would cost about $84 to produce a kilogram of natural uranium from 0.2 percent depleted uranium.

Table IV.3: Cost of Reenriching Tails[a]

Cost per SWU	Cost to produce 1 kilogram of natural uranium[b]
$ 25	$ 42.03
50	84.05
75	126.08
100	168.10

[a]The table assumes that the depleted tails being enriched are at a 0.2-percent enrichment level and that the tails assay of the reenrichment process is 0.15 percent.

[b]Uranium hexafloride (UF_6) enriched with U-235 to 0.711 percent.

Currently, the cost of a kilogram of natural uranium hexafloride is about $24. Therefore, according to the chart, the price of a SWU used in the reenrichment process would need to drop to well below $25 or the price of natural uranium would have to rise substantially above its current level before it would be economical to reenrich depleted tails for use in future enrichment activities.

DOE's Proposed Uranium Inventory Sale or Barter

In 1992 DOE's Office of Defense Programs identified about 8,736 metric tons of depleted, natural, and enriched uranium in various forms as excess material that could be sold or bartered. The excess inventories are at DOE facilities located at Fernald, Ohio, and Hanford, Washington. As Table IV.4 illustrates, most of these inventories consists of enriched and depleted uranium.

Table IV.4: Excess DOE Uranium Inventories Identified for Potential Sale

In metric tons

Location	Natural uranium	Enriched uranium	Depleted uranium	Total
Hanford, Wash.	147	2,040	115	**2,302**
Fernald, Ohio	450	2,159	3,825	**6,434**
Total	597	4,199	3,940	**8,736**

According to DOE officials, some of this material cannot be fed through DOE's enrichment plants because it is in metal form; furthermore, it has various impurities that would not be acceptable by U.S. nuclear fuel fabricators. However, some foreign facilities have expressed interest in this material. DOE prefers to exchange the natural and enriched uranium for commercial natural uranium that can be used in its gaseous diffusion plant operations.

DOE officials published requests for written expressions of interest in the March 24, 1992, and April 9, 1992, editions of the Commerce Business Daily for its Fernald and Hanford inventories and are currently reviewing responses. DOE officials told us that they will proceed with caution in conducting these sales and/or exchanges because they do not want to cause injury to the U.S. uranium mining industry.

Major Contributors to This Report

Resources, Community, and Economic Development Division, Washington, D.C.

James E. Wells, Jr., Associate Director
Robert E. Allen, Jr., Assistant Director
Ronald E. Stouffer, Evaluator-in-Charge
Elise B. Bornstein, Evaluator
Earl P. Williams, Jr., Reports Analyst